

# **THEODORE ROOSEVELT NATIONAL PARK**

**ND PRA THRO 11(5)**

**PAVEMENTS REPORT  
REPORT #11-01**



## SIGNATURE SHEET

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## **RECOMMENDED PAVEMENT TYPICAL STRUCTURAL SECTION**

### **Option 1: SOUTH LOOP ROAD**

3.5 inches HACP

7 inches FDR - Stabilization

## **I. INTRODUCTION AND BACKGROUND**

This report presents pavements recommendations for ND PRA THRO 11(5) South Loop Road in Theodore Roosevelt National Park. The report addresses recommendations, findings, analysis, and discussions regarding:

- Pavement alternatives
- Existing pavement and subgrade conditions
- Field investigations
- Laboratory analysis

The project covers a length of 10.67 miles of South Loop Road, beginning at the Medora park entrance and continuing north. This report also includes a pavement recommendation for Buck Hill Spur, which is located off of South Loop Road near milepost (MP) 17. Figure 1 below provides a location map. Appendix A shows a larger site map. Buck Hill Spur may or may not be part of ND PRA THRO 11(5).

South Loop Road is also known as Scenic Loop Road (Route 11) in the Road Inventory Program (RIP) data, South Unit Loop Road on the project schedule, and is labeled as East River Road on most maps. For this memo South Loop Road will be used. Buck Hill Spur is also known as Buck Hill on most maps.

## ND PRA THRO 11(5) South Loop Road

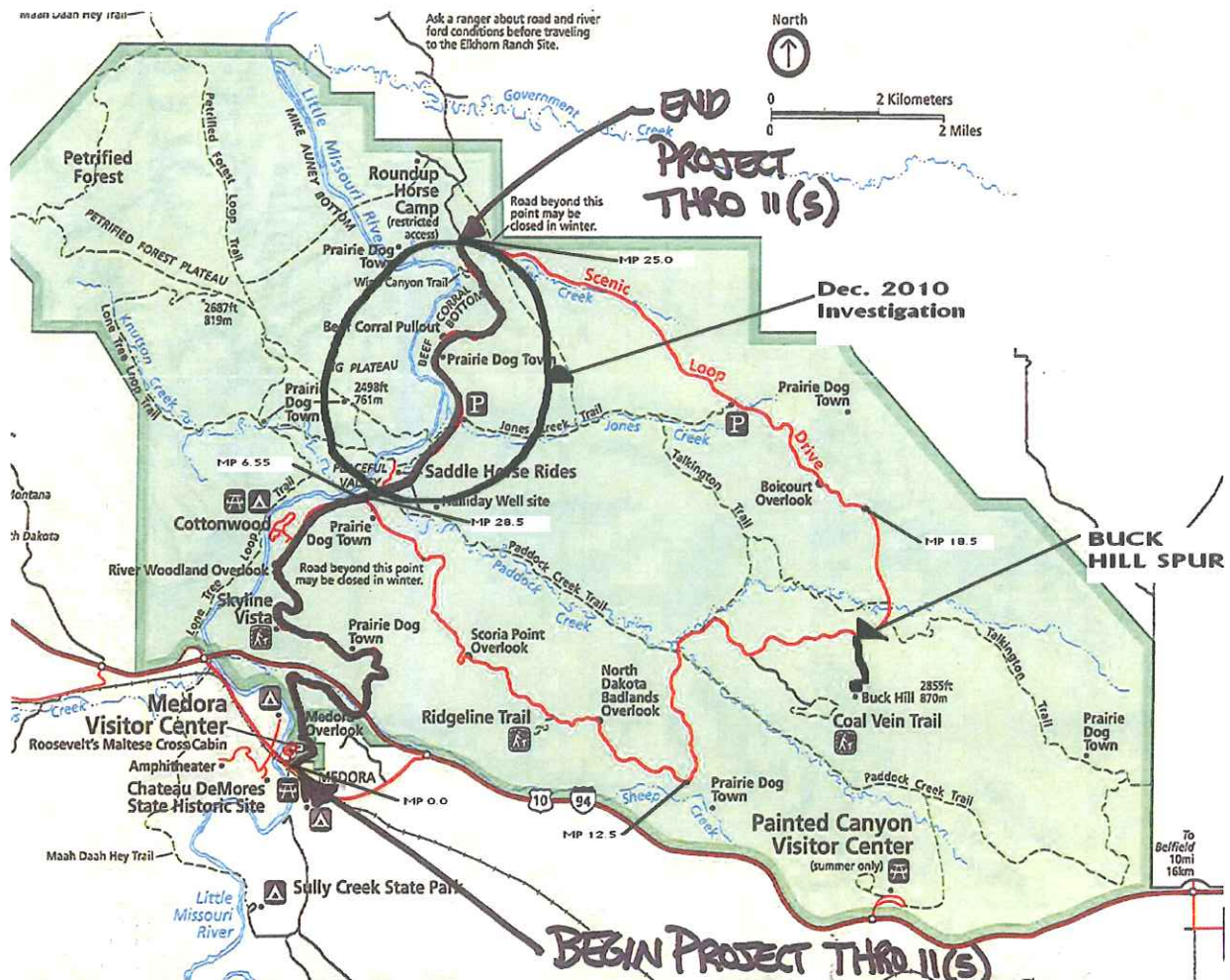


Figure 1. Project Location Map. Shows the mileposts where the project starts and stops and Buck Hill Spur.

The mileposts begin 0.0 at the Medora Visitor Center and proceed north to milepost 6.55/28.5 at the southern intersection of South Loop Road and Scenic Loop Drive. The mileposts continue counterclockwise along the loop to milepost 25.0 at the northern intersection of South Loop Road and Scenic Loop Drive. The mileposts then continue south along South Loop Road back to milepost 28.5/6.55 at the southern intersection of South Loop Road and Scenic Loop Drive. Figure 1 above and Appendix A show the labeled mileposts along the road.

A 1993 pavements report by Samuel Holder for South Loop Road contains pavement, base, subgrade classifications and R-Values from milepost 0.0 to 6.55. A field investigation was performed on December 1<sup>st</sup> by Central Federal Lands to record pavement conditions and gather samples from milepost RIP MP 28.5 to 25.0. The 1993 pavements report was used during this investigation to determine the change in pavement thickness over the years as well as previous pavement design types applied to the road.

## II. EXISTING PAVEMENT AND SUBGRADE CONDITIONS

### South Loop Road

The existing roadway is an average of 20.5-feet wide with 3-foot paved ditches and asphalt curbs at various locations. The existing asphalt pavement is highly distressed throughout the entire length of the project. The main distress apparent is thermal cracking, spaced approximately every 20 to 30 feet, due to low temperature cracking. Several locations in the roadway mainline show rutting. These areas may require subexcavation. Large dips were also found, possibly due to poorly compacted or collapsing culverts under the roadway.

Records show that South Loop Road was last chip sealed in 1997. Patching is found in multiple areas over the chip seal. Existing pavement thickness varies from 4.5 inches to 7.5 inches on the mainline. The existing pavement thickness is 3.0 inches in Wind Canyon and Jones Creek pullouts. This indicates an additional 1-inch of added asphalt from the overlapping 1993 data. The additional patching and possible overlay may be the cause of this. The aggregate base material varies in thickness from 5.5-inches to 7.0-inches. Table 1 below shows pavement, base, and subgrade thicknesses from both the field investigation and the 1993 pavements report. Figure 2 shows the existing pavement thickness along the mainline of South Loop Road. Fabric existed from RIP MP 28.5 to 25.0.



**Figure 2. Pavement Thickness.** MP 25.4 Rt. South Loop Road, B-1, Pavement thickness at a dip in the road.

**Table 1.** Thicknesses for pavement, base, and subgrade from 1993 investigation and 2010 investigation

ND PRA THRO 11(5) Recorded Thicknesses							
Location (M.P.)*	Boring	Side	Asphalt Pavement (1993)	Asphalt Pavement (2010)	Fabric	Base Course	HACP + Base
0.5	B1	Rt	4.5"	-		4.5"	9"
1.0	B2	Rt	5"	-		4"	9"
1.5	B3	Rt	9"	-		3"	12"
2.0	B4	Rt	6.5"	-		1.5"	8"
2.5	B5	Rt	6"	-		3"	9"
3.0	B6	Rt	9"	-		-	9"
3.5	B7	Rt	5.5"	-		2.5"	8"
4.0	B8	Rt	7"	-		-	7"
4.5	B9	Rt	7.5"	-		3"	10.5"
5.0	B10	Rt	7"	-		1.5"	8.5"
5.5	B11	Rt	5.5"	-		4.5"	10"
6.0	B12	Rt	7.5"	-		1.5"	9"
6.5	B13	Rt	6.5"	-		2.5"	9"
25.4	B1	Rt	12"	4.5"	Yes	11"	15.5"
26.1	B2	Lt	4.5"	5.5"	Yes	5.5"	11"
26.2	B3	Rt	4.5"	5.5"		5"	10.5"
27.0	B4	Lt	5.5"	6.5"	Yes	5"	11.5"
27.5	B5	Rt	7.5"	7.5"	Yes	7"	14.5"
27.9	B6	Lt	5"	6.5"	Yes	6.5"	13"
28.6	B7	Rt	2"	4.5"	Yes	5"	9.5"
6.0	B8	Rt	-	7.5"	Yes	4.5"	12"
Wind Canyon Pullout	P1	-	-	3"		9"	12"
Jones Creek Pullout	P2	-	-	6.5"		0"	6.5"
<b>Average</b>			<b>6.67</b>	<b>5.79</b>	<b>6.23**</b>	<b>3.86</b>	<b>10.26</b>
* Mileposts scaled with site map. Mileposts in this table may vary from actual field mileposts.							
** Average asphalt pavement depth of entire project							

**Buck Hill Spur**

The existing roadway is 0.73 miles long with an average width of 25.5-feet with 4-foot paved ditches and asphalt curb. The existing asphalt pavement is highly distressed throughout the entire length of the project. Loose aggregate is found in many areas where drainage is a problem.

The existing pavement thickness averages 3-inches on the mainline, although in some areas the pavement thickness is less than 1-inch. A culvert at milepost 0.1 collects runoff from an existing natural slope. The water drains across the road causing damage to the roads surface. From milepost 0.4 to 0.5 a large dip in the road is causing water to puddle on a regular basis making the road only accessible to 4-wheel drive vehicles. The asphalt has been stripped away in this area. Photographs of the culverts can be found in Appendix E.

The scoria base material varies in thickness from 12 to 23-inches. Table 2 below shows pavement and scoria base thickness from the field investigation.

**Table 2.** Thicknesses for pavement and scoria base from the investigation.

ND PRA THRO 11(5) Recorded Thicknesses				
Location (M.P.)	Boring	Asphalt Pavemen	Scoria Base	HACP + Base
0.4	B1	0"	12"	12"
0.5	B2	3"	20"	23"

### III. FIELD INVESTIGATIONS (2010)

#### South Loop Road

On December 1, 2010, a two person crew from Braun Intertec was contracted to drill borings using a CME 75 truck-mounted drill rig. Drilling started on the north end where Scenic Loop Drive and South Loop Road intersect at milepost 25.5 and continued south to milepost 28.5. Snow and ice patches were on the roadway.

Pavement, base, and subgrade samples were collected for laboratory testing to determine R-Values, gradations, and soil classifications. Six 1-foot borings holes were drilled to determine pavement and base thicknesses. Two of those boring holes were drilled in Wind Canyon Pullout and Jones Creek Pullout. Four 5-foot boring holes were also drilled to determine pavement, base, and subgrade thicknesses. All boring hole locations were determined by FHWA and were chosen based off of visual areas of distress. The field investigation log for this site visit is in Table 2 in Appendix B at the back of this report. Figure 3 below shows photographs of the base material found during the investigation. Figure 4 shows photographs of the subgrade material found. Additional photographs of the boring holes and soils found can also be found in Appendix D.



**Figure 3. Base Material.** Jones Creek Pullout, P-2, Base material.



Figure 4. Subgrade Material. MP 26.2 Rt. South Loop Road, B-3, Subgrade material.

### **Buck Hill Spur**

Pavement, base, and subgrade samples were collected for laboratory testing to determine R-Values, gradations, and soil classifications. The first sample was at milepost 0.4 where a large dip can be seen in the roadway. The second boring hole was drilled at milepost 0.5 just above where rippling can be seen in the roadway. The field investigation log for this site visit is in Table 2 in Appendix B at the back of this report. Additional photographs of the boring holes and soils found can also be found in Appendix E.

## **IV. TEST RESULTS**

### **South Loop Road**

Samples were tested for soil classification, R-Values, and pH levels. No base course was collected from milepost 0.0 to 6.5. The base course mostly consists of silty clayey sands from RIP MP 28.5 to 25.0. From RIP MP 28.5 to 25.0, the subgrade material consists of sandy clay and the R-Values range from <5 to 16. These R-values are much lower than the R-values recorded from milepost 0.0 to 6.5 in the 1993 pavements report, which range from 65 to 79. The subgrade samples collected in 1993 might have consisted of a base-subgrade mixture resulting in higher R-Values. The boring depths from the 1993 report are much lower, ranging from 7 to 12 inches. In the 2010 investigation, boring holes were drilled to a depth of 60 inches. The subgrade was also tested for hot soils resulting in a pH of 6.8 and a resistivity of 418 ohm x cm. Table 3 below provides the soils classifications, R-Values and plasticity index for the subgrade material.

Table 3. Classification, R-Values, and plasticity index for the subgrade.

ND PRA THRO 11(5) Recorded Thicknesses							
Location (M.P.)*	Boring	Side	Sample Depth	AASHTO Classification	R-Value (1993)	R-Value (2010)	Plasticity Index
0.5	B1	Rt	9" - 1' 6"	A-2-4 (0)	79	-	NP
1.0	B2	Rt			-	-	
1.5	B3	Rt			-	-	
2.0	B4	Rt	8" - 1' 10"	A-2-4 (0)	65	-	6
2.5	B5	Rt			-	-	
3.0	B6	Rt			-	-	
3.5	B7	Rt	8" - 1' 8"	A-1-b (0)	76	-	NP
4.0	B8	Rt			-	-	
4.5	B9	Rt			-	-	
5.0	B10	Rt	8.5" - 1' 8"	A-2-4 (0)	69	-	6
5.5	B11	Rt			-	-	
6.0	B12	Rt			-	-	
6.5	B13	Rt	9" - 2' 1"	A-2-4 (0)	60**	-	7
6.0	B8	Rt			-	-	
28.6	B7	Rt	9.5" - 5'	A-6 (13)	-	8	21
27.9	B6	Lt	13" - 5'	A-6 (16)	-	<5	19
27.5	B5	Rt			-	-	
27.0	B4	Lt			-	-	
26.2	B3	Rt	10.5" - 5'	A-6 (21)	-	11	22
26.1	B2	Lt			-	-	
25.4	B1	Rt	15.5" - 5'	A-6 (14)	-	16	19
Wind Canyon Pullout	P1	-			-	-	
Jones Creek Pullout	P2	-			-	-	

\* Mileposts scaled with site map. Mileposts in this table may vary from actual field mileposts.

\*\* Did not use value in R-Value calculation. Milepost 28.6 and 6.55 are at the same location. Used R-value of 8 at this location.

Since the R-Values for the subgrade material were so low, combinations of the base and HACP were tested to try and raise the Structural Number (SN) and create a more stable and cost efficient structure. Four combinations were combined and tested for R-Values. The combinations consisted of 0% RAP and 100% base, 25% RAP and 75% base, 50% RAP and 50% base, and 75% RAP and 25% base. Table 4 below shows the R-Values for each of the combinations.

Table 4. R-Values for combinations of RAP and base material.

Combination % RAP / % Base	R-Value
0 / 100	58
25 / 75	60
50 / 50	76
75 / 25	77

Using the results from the field investigation and previous pavements report on South Loop Road, it was determined that a 7-inch FDR – Stabilization with 5% Fly Ash or 3% Lime and 3.5-inches of new HACP overlay would be the recommended pavement design.

### **Buck Hill Spur**

The Buck Hill Spur samples were also tested for soil classification and R-Values. Base course mostly consisted of scoria base. The subgrade material consisted of clays. The subgrade material has an R-Value of <5, a pH of 7.3, and a resistivity value of 340 ohm x cm.

It was determined that 4-inches of FDR – Stabilization with 5% Fly Ash or 3% Lime, 2-inches of aggregate base material, and 3.5-inches of new HACP overlay would be the recommended pavement design. Theodore Roosevelt has natural silty clay soils and months of snow and cold weather making a thick stable base essential for lasting pavement.

## **V. PAVEMENT RECOMMENDATIONS & DISCUSSIONS**

### **South Loop Road**

The average daily traffic for South Loop Road was calculated by using park traffic data for the Medora entrance station from 1992 through 2010. The growth rate was calculated to be 1% and the amount of traffic was projected out to 2030. During the field investigation fabric was found from RIP MP 28.5 to 25.0; however it is anticipated that the pulverizer will be able to tear through the fabric. Production time may slow for periodic removal of fabric from the road reclaimers teeth.

The required design Structural Number (SN) on the subgrade material is 2.72. The average existing HACP, existing base course, and existing HACP- base course combination thickness is 6-inches, 3.5-inches, and 10-inches respectively. Below shows two options with Option 1 as the recommended option.

#### **Option 1: RECOMMENDED**

3.5 inches HACP

7 inches FDR - Stabilization

SN = 2.73

Cost Estimate (5% Fly Ash) = \$327,649 per mile, paving cost only

Cost Estimate (3% Lime) = \$324,284 per mile, paving cost only

#### **Option 2:**

4 inches HACP

7 inches FDR - Pulverize

SN = 2.74

Cost Estimate = \$328,247 per mile, paving cost only

The recommended pavement rehabilitation is 7-inches of Full Depth Reclamation (FDR) - stabilization with either 5% Fly Ash or 3% Lime with 3.5-inches of new Hot Asphalt Concrete Pavement (HACP) overlay. This recommendation is based on traffic information,

potential loadings, existing pavement, and soil conditions. This method will provide better bridging over the clayey soils that are found in this area. This method also provides better constructability and results in a lower grade. The complete cost estimation is in Appendix H. The recommendation and cost estimate is for mainline only and does not include pullouts, parking areas, or paved ditches.

It is important to note that the borings were between a quarter and half a mile apart, as a result discrepancies between the report and actual field thickness could occur.

### **Buck Hill Spur**

The calculated and required design structural number (SN) based on the above material is 2.72. Two options are recommended, a 3R option and a 4R option. The 3R option will only be used if Buck Hill Spur is incorporated with ND PRA THRO 11(5) or if recycling is allowed for a standalone project. The recommended options for Buck Hill Spur are shown below.

#### **3R Option**

3.5 inches HACP

2 inches Aggregate Base Course

4 inches FDR-Stabilization

SN = 2.74

Cost Estimate (5% Fly Ash) = \$463,834 per mile, paving cost only

Cost Estimate (3% Lime) = \$460,247 per mile, paving cost only

#### **4R Option**

4 inches HACP

7 inches Aggregate Base Course

SN = 2.72

Cost Estimate = \$551,338 per mile, paving cost only

The recommended 3R pavement rehabilitation is 4-inches of FDR-stabilization with either 5% Fly Ash or 3% Lime, 2 inches of aggregate base course, and 3.5-inches of new HACP. This recommendation is based on traffic information, potential loadings, public access, existing pavement, subgrade, and soil conditions.

The recommended 4R pavement rehabilitation is 7-inches of aggregate base course, and 4-inches of new HACP.

The existing base material is scoria with an R-Value of less than 5. It is recommended that 2-inches of new base be brought in and placed along the roadway. The contractor may choose to pulverize and recycle the existing roadway. The recycled material should be used as the bottom 4-inches of base course. If the existing pavement is recycled base material, it should conform to section 303.08 in the SCRs. Pulverized material may not be hauled out of the park. The complete cost estimation is in Appendix G.

A large dip in the road at approximately milepost 0.4 to 0.5 is causing drainage issues and will need to be filled with unclassified borrow of A-2-4 material or better. It will take approximately 7,800 ft<sup>3</sup> of material to raise the dip. This is based off of a 5-foot depth, 25-foot width, and 125-foot length. This quantity was based on visual approximations and was not actually measured. To solve this it is recommended that 5' of full width subexcavation be done. Install geogrid at a 2-foot spacing, with the first layer at the bottom, for a total of 3 layers. Install geosynthetic separation material Type IV-F between the natural existing clay material and the aggregate base course. Construct roadway with a 2% slope to allow water to drain to shoulder and or edge drain. It is also recommended that a possible culvert or under drain be installed in that area. This base quantity and cost estimate does take into account this quantity. Hydraulics and Geotech will need to look into the issue further.

## **VII. MATERIALS RECOMMENDATIONS**

### **Drainage, Subexcavation, and other Issues**

During the field investigation of December 2010, there were no major water or drainage problems that were evident along South Loop Road; however the field investigation was performed during below freezing temperatures in December when drainage issues may not have been evident. Due to the clayey subgrade beneath South Loop Road, it will be imperative that a prime seal be placed immediately onto the pulverized base material once that material is finished to grade. The prime seal will aid, along with proper grading, in shedding rainwater. If water is allowed to penetrate through unsealed base material, the subgrade will deteriorate and subexcavation may become necessary.

Another strategy to prevent saturation of the subgrade soils and structural damage is to rewrite the 303 SCR to conform to the following limitations:

- Do not begin pulverization operations until the Superpave Pavement mix design has been submitted and approved by the CO.
- Pulverize the roadway in segments no greater than 2.5 lane miles at any time.
- Apply prime coat to the pulverized material within 5 work days of pulverization beginning.
- Apply the first lift of Superpave Pavement to the primed segment within 14 working days of beginning of pulverization.
- Construction equipment including hauling trucks will be required to travel as much as practical on paved sections and minimize the traffic loading on the pulverized material.

If subexcavation becomes necessary, follow the guidelines in the table below. The table is from Chapter 11 of the Project Development Design Manual (PDDM). Based on the soil classification testing it appears most of the subgrade would fall into the 2 feet depth category. To account for areas that may need to be subexcavated, 2000 tons of subexcavation should be put in the contract to be used at the discretion of the CO. If paved waterways are installed, add a 608 item to the contract.

**Table 5.** Subexcavation guidelines.

Plasticity Index (PI)	Liquid Limit (LL)	Depth of Subexcavation*
15 - 25	< 50	2 feet
25 - 35	50 - 60	2 - 4 feet
> 35	> 60	4 - 6 feet

\* Traffic volume, project significance, and results of AASHTO T 258 and T 92 should influence subexcavation depth.

### **Selection of Asphalt Binder**

LTTPBind software indicates use of PG 58-34 at 98% reliability.

### **Pavement Materials**

- 30305-0000 - Pulverizing 7-inch depth.
- 30310-0000 - Fly Ash, Estimate at 142.1 lb/ft<sup>3</sup>.
- 30311-0000 - Lime, Estimate at 142.1 lb/ft<sup>3</sup>.
- 30802-2000 – Roadway Aggregate, Method 2. Estimate at 139 lb/ ft<sup>3</sup>. Place 2-inches of base material at Buck Hill Spur.
- 40101-5600 – Superpave Pavement, ½-inch or ¾-inch nominal maximum size aggregate, 0.3 to <3 million ESALs. Estimate at 145 lb/ft<sup>3</sup>. Asphalt cement will be PG 58-34. Type IV Roughness to be specified.
- 40105-3000 - Antistrip will be Type III (Hydrated Lime at 1%).
- 40920-1000 - Fog Seal, use an emulsion CSS-1, CSS-1h, SS-1, or SS-1h estimate at 0.10 gal/yd<sup>2</sup>
- 41101-3000 - Prime Coat, applied to the FDR-Pulverized material prior to paving. Use and emulsion CSS-1, CSS-1h, SS-1, or SS-1h estimate at 0.33 gal/yd<sup>2</sup>.
- 41106-0000 - Item for blotter control should be included at 14.75 lb/ft<sup>2</sup>.
- 41201-0000 - Tack Coat, HACP shall be placed in two lifts with a tack coat in between lifts. Use an emulsion CSS-1, CSS-1h, SS-1, or SS-1h, estimate at 0.10 gal/yd<sup>2</sup>.

## APPENDIX A

### SITE MAP



## APPENDIX B

### FIELD INVESTIGATION AND TESTING SUMMARIES

# ND PRA THRO 11(5) THEODORE ROOSEVELT FIELD LOG

Cloudy, 20F, Snow and ice patches in roadway  
 Start at MP 25.0 at northern intersection of South Loop Road and Scenic Loop Drive looking toward higher milepost  
 Buck Hill - Start at intersection looking up Buck Hill Spur  
 Thermal Cracks every 20' to 30' (Use polymerized binder 58-34 or 64-34)

Possible subex areas

chip sealed in 1997 and later did patching

CME 75 Drill Rig

\*Miles plan mile posts are slightly off from mileposts on site

South Loop Road	Boring	Width (ft)	Lane	Log	Description	Note	Photo #	AASHTO M	ASTM D 2487	R-Value	PI	#200	#4
MP 25.4	B1	26 roadway 6 of paved ditch and gutter	Rt	0" - 4.5" 4.5" - 15.5" 15.5" - 60"	HACP red brown clay gravel brown clay	HACP 1 Base 1 Subgrade 1  Possible culvert (dip in roadway) Coordinates: N 46 59.3127' W 103 29.0830	last 3 in Dave's camera 1	A-2-4 (0) A-6 (14)	SC-SM CL	53 16	7 19	76 83	100
Wind Canyon Pullout	P1			0" - 3" 3" - 12"	HACP red brown gravelly sand	HACP 1  At 25.8 chip seal with and patching Coordinates: N 46 59.3256' W 103 29.1114'	237 - 243 in Dave's camera						
MP 26.1	B2	20 roadway 3 of paved ditch and asphalt curb	Lt	0" - 5.5" 5.5" - 11" 11.5" - 60"	HACP with fabric dark brown silty clay	HACP 1  1993 pavements report recorded 4.5" HACP 1993 pavements report recorded 5.5" base Coordinates: N 46 58.8860' W 103 28.7156'	2, 3, 4, 5						
MP 26.2 (26 on site)	B3	20.5	Rt	0" - 5.5" 5.5" - 11.5" 11.5" - 60"	HACP dark brown/ med. silty clay (asphalt treated) grey clay	HACP 1 Base 2 Subgrade 2 Bore in a patch Coordinates: N 46 58.8021' W 103 28.8409'	6, 7, 8, 9, 10, 11	A-1-b (0) A-6 (21)	SM CL		NP 22	16 93	75 100
MP 27.0	B4	20	Lt	0" - 6.5" 6.5" - 11.5"	HACP with fabric medium brown silty gravel	HACP 1 Base 2  1993 pavements report recorded 5.5" HACP 1993 pavements report recorded 5" base Coordinates: N 46 58.7171' W 103 29.0524'	12, 13, 14	A-1-b (0)	SM		NP	16	75
MP 27.5	B5	20.5	Rt	0" - 7.5" 7.5" - 14.5"	HACP with fabric medium brown silty clay	HACP 1 Base 2  1993 pavements report recorded 7.5" HACP 1993 pavements report recorded 7" base Coordinates: N 46 58.5648' W 103 29.5870'	15, 16, 17, 18	A-1-b (0)	SM		NP	16	75
MP 27.9	B6	20.5	Lt	0" - 6.5" 6.5" - 13" 13" - 60"	HACP with fabric dark brown/ med. silty gravel (asphalt treated) grey clay	HACP 1 base 3 subgrade 2 possible cut Coordinates: N 46 57.8817' W 103 29.3569'	22, 23, 24, 25	A-1-b (0) A-6 (16)	SC-SM CL	33 <5	6 19	18 89	77 96
MP 28.6	B7	20.5	Rt	0" - 4.5" 4.5" - 9.5" 9.5" - 60"	HACP with fabric medium brown silty gravel dark brown silty clay	Base 4 Subgrade 4 Coordinates: N 46 57.4578' W 103 29.9510'	26, 27, 28, 29	A-2-4 (0) A-6 (13)	SC-SM CL		7 8	19 21	75 97
MP 6.0	B8	21	Rt	0" - 7.5" 7.5" - 12" 0" - 6.5"	HACP with fabric medium brown gravelly sand  no base	Base 2 HACP 1 no recovery Coordinates: N 46 57.9876' W 103 29.2283'	30, 31, 32  19, 20, 21	A-1-b (0)	SM		NP	16	75

Jones Creek Pullout

P2

<u>Buck Hill Spur</u>	<u>Boring</u>	<u>Width (ft)</u>	<u>Lane</u>	<u>Log</u>	<u>Description</u>	<u>Note</u>	<u>Photo #</u>	<u>AASHTO M</u>	<u>ASTM D 2487</u>	<u>R-Value</u>	<u>PI</u>	<u>#200</u>	<u>#4</u>
MP 0.4	B1	25 roadway 4 of paved ditch	Rt	0" - 12"	gravel scoria Base red brown clay	B1 Buck Hill Rd. Subgrade Coordinates: N 46 55.8930' W 103 23.2709'		A-2-4 (0) A-7-6 (28)	SC CL	<5	9 29	25 93	70 100
MP 0.5	B2	26 roadway 4 of paved ditch	Rt	0" - 3" 3" - 23"	HACP scoria Base red brown clay	B2 Buck Hill Rd. Subgrade Coordinates: N 46 55.7634' W 103 23.2274'		A-2-4 (0)	SC		9	25	70

## APPENDIX C

### LABORATORY TEST RESULTS



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

# Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory



## Report of Soil or Aggregate Tests

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**Project:** North Dakota PRA THRO 11(5) South Loop Road (East River Road)

**Submitted By:** Danielle Germani

**Date Reported:** 1/20/2011

Sample Number	Lab Number	10-3848-AGG	10-3849-AGG	10-3850-AGG	10-3851-AGG	Combined
	Hole Number	B-1	B-3, B-4 B-5, B-8	B-6	B-7	
	Field Number	Base 1	Base 2	Base 3	Base 4	
Sample Location	East River Road Milepost And Offset	25.4 Right	26.2 Right 27.0 Left 27.5 Right 29.0 Right	27.9 Left	28.6 Right	
	Depth	4.5" -15.5"	Varies	6.5"-13"	4.5"-9.5"	
AASHTO T 11, T 27 & T 88  Washed Sieve Analysis % Passing	1"	25.0 mm		100		
	3/4"	19.0 mm	100	100	98	100
	1/2"	12.5 mm	96	97	95	96
	3/8"	9.5 mm	91	92	91	91
	#4	4.75 mm	76	75	77	76
	#8	2.36 mm	63	62	64	64
	#10	2.00 mm	60	59	61	61
	#16	1.18 mm				
	#30	600 µm	40	39	39	42
	#40	425 µm	35	33	34	37
	#50	300 µm	32	29	30	33
	#200	75 µm	19	16	18	19
		20 µm				
		2 µm				
		1 µm				
AASHTO T 255	Moisture, %					
AASHTO T 89 & T 90	Liquid Limit	22	NV	21	22	22
	Plasticity Index	7	NP	6	7	7
Soil Classification	AASHTO M 145	A-2-4 (0)	A-1-b (0)	A-1-b (0)	A-2-4 (0)	A-2-4 (0)
	ASTM D 2487	SC-SM	SM	SC-SM	SC-SM	SC-SM
AASHTO T 190	R - Value	53		33		
AASHTO T 288	Min. Resistivity, ohm x cm					
AASHTO T 289	pH					
AASHTO Method	Optimum Moisture, %					
	Maximum Dry Density, pcf					

**Distribution:** Num. / Project File  
Laboratory Darrell Harding  
Pavements Danielle Germani  
Pavements Steve Deppmeier  
Materials Mike Peabody

**Remarks:** The combined base course gradation is a mathematical blend of the 4 base samples.  
The liquid limit and plasticity index is from testing the actual blend.

**Reported By:**

Darrell Harding  
Laboratory Manager



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

# Central Federal Lands Highway Division Laboratory

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## Report of Soil or Aggregate Tests

Page 1 of 5

**Project:** North Dakota PRA THRO 11(5) South Loop Road (East River Road)

**Submitted By:** Danielle Germani

**Date Reported:** 1/20/2011


Sample Number	Lab Number		10-3841-RV	10-3842-RV	10-3843-AGG	10-3844-AGG	
	Hole Number		B-1	B-3	B-6	B-7	
	Field Number		Subgrade 1	Subgrade 2	Subgrade 3	Subgrade 4	
Sample Location	East River Road - Milepost		25.4	26.2	27.9	28.6	
	Offset		Right	Right	Left	Right	
	Depth		15.5"-5'	10.5"-5'	13"-5'	9.5"-5'	
AASHTO T 11, T 27 & T 88  Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm					
	1"	25.0 mm					
	3/4"	19.0 mm					
	1/2"	12.5 mm				100	
	3/8"	9.5 mm			100	99	
	#4	4.75 mm	100	100	96	97	
	#8	2.36 mm					
	#10	2.00 mm	97	99	95	94	
	#16	1.18 mm	96	98	95	91	
	#30	600 µm					
	#40	425 µm	94	97	93	87	
	#50	300 µm					
	#100	150 µm	91	96	92	84	
	#200	75 µm	83	93	89	74	
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		34	39	34	35	
	Plasticity Index		19	22	19	21	
Soil Classification	AASHTO M 145		A-6 (14)	A-6 (21)	A-6 (16)	A-6 (13)	
	ASTM D 2487		CL	CL	CL	CL	
AASHTO T 190	R - Value		16	11	<5	8	
AASHTO T 288	Min. Resistivity, ohm x cm				418		
AASHTO T 289	pH				6.8		
AASHTO T 290	Sulfate Ion Content, %/ppm				0.844 / 8440		
AASHTO T 291	Chloride Ion Content, %/ppm				0.0004 / 4		

**Distribution:** Num. / Project File  
 Laboratory Darrell Harding  
 Pavements Danielle Germani  
 Pavements Steve Deppmeier  
 Materials Mike Peabody

**Remarks:**

Sulfate & chloride content testing was performed by FHWA consultant, Colorado Analytical Laboratories.

**Reported By:**

  
 Darrell Harding  
 Laboratory Manager



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

# Central Federal Lands Highway Division Laboratory

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## Report of Asphalt Concrete Mixture Tests

Project: North Dakota PRA THRO 11(5) South Loop Road (East River Road) Submitted By: Danielle Germani Date Reported: 1/20/2011

Lab Number	10-3852-AGG		
Hole Number	B1, B2, B3, B4, B5, B6, P1, P2		
Sample Location	East River Road @ Milepost / Offset	25.4 / Rt, 26.1 / Lt 26.2 / Rt, 27.0 / Lt 27.5 / Rt, 27.9 / Lt	

Item:	Class:	Sieve Size	Gr., Spec.	T.V.	(D)
AASHTO T 30		3/4"	19.0 mm		100
		1/2"	12.5 mm		97
		3/8"	9.5 mm		89
		#4	4.75 mm		73
		#8	2.36 mm		51
		#30	600 µm		26
		#40	425 µm		22
		#50	300 µm		18
		#200	75 µm		8.2
		Asphalt Content, % by Total Mix Weight			7.82
Field Cores		Density, pcf		AASHTO T 166	
		Absorption, %		AASHTO T 166	
		Density, pcf		AASHTO T 331	
		Compaction, %			
Loose Asphalt Mixture Received From Field		Thickness, inches		ASTM D 3549	
		Moisture Induced Damage AASHTO T 283			
		Conditioned Strength, psi			
		Dry Strength, psi			
		Tensile Strength Ratio, %			
		Air Voids, %			
		Maximum Density, pcf		AASHTO T 209	
		Hveem Specimen AASHTO T 246			
		Stabilometer value			
		Density, pcf			
		Air Voids, %			

**Distribution:**  
Laboratory  
Project Engineer  
Construction  
Materials

Num / Project File  
Darrell Harding  
Danielle Germani  
Steve Deppmeier  
Mike Peabody

**Remarks:** This material is existing HACPC.  
The sample contained both fabric and chip seal.

**Reported By:**  
  
Darrell Harding  
Laboratory Manager



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

# Central Federal Lands Highway Division Laboratory

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## Report of Soil or Aggregate Tests

Page 4 of 5

**Project:** North Dakota PRA THRO 11(5) South Loop Road

**Submitted By:** Danielle Germani

**Date Reported:** 1/20/2011

Sample Number	Lab Number	Combined	Combined	Combined	Combined	
	Hole Number					
	% RAP / % Base	0 / 100	25 / 75	50 / 50	75 / 25	

Sample Location	Milepost or Location					
	Offset					
	Depth					

AASHTO T 11, T 27 & T 88  Washed Sieve Analysis % Passing	3"	75.0 mm				
	1 1/2"	37.5 mm				
	1"	25.0 mm				
	3/4"	19.0 mm	100	100	100	100
	1/2"	12.5 mm	96	96	97	97
	3/8"	9.5 mm	91	91	90	90
	#4	4.75 mm	76	75	75	74
	#8	2.36 mm	64	61	58	54
	#10	2.00 mm				
	#16	1.18 mm				
	#30	600 µm	40	37	33	30
	#40	425 µm	35	32	29	25
	#50	300 µm	31	28	25	21
	#100	150 µm				
	#200	75 µm	18	16	13	11
		20 µm				
		2 µm				
		1 µm				

AASHTO T 255	Moisture, %				
AASHTO T 89 & T 90	Liquid Limit				
	Plasticity Index				
Soil Classification	AASHTO M 145				
	ASTM D 2487				
AASHTO T 190	R - Value	58	60	76	77
AASHTO T 288	Min. Resistivity, ohm x cm				
AASHTO T 289	pH				
AASHTO Method	Optimum Moisture, %				
	Maximum Dry Density, pcf				

**Distribution:** Num. / Project File  
Laboratory Darrell Harding  
Pavements Danielle Germani  
Pavements Steve Deppmeier  
Materials Mike Peabody

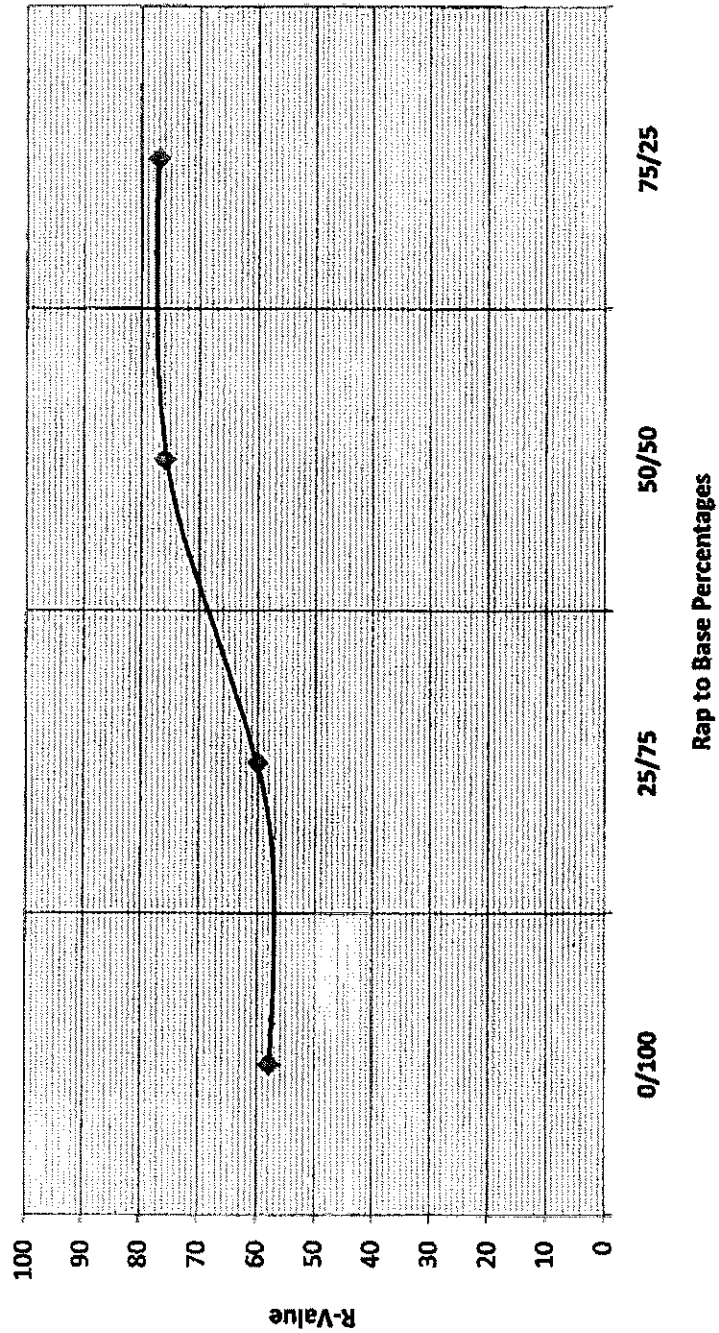
**Remarks:** This material is a blend of existing pavement and aggregate base.

**Reported By:**

*Darrell Harding*

Darrell Harding  
Laboratory Manager

# **R-Value Graph for ND PRA THRO 11(5) South Loop Road** **Various RAP-Base Ratios** **(10-3848-3852-AGG)**





U.S. Department  
of Transportation  
**Federal Highway  
Administration**

# Central Federal Lands Highway Division Laboratory

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## Report of Soil or Aggregate Tests

Page 1 of 1

**Project:** North Dakota PRA THRO 11(5) South Loop Road (Buck Hill)

**Submitted By:** Danielle Germani

**Date Reported:** 1/20/2011

Sample Number	Lab Number	10-3845-RV		10-3847-AGG		
	Hole Number	B-1		B-1 & B-2		
	Field Number	B-1 Buck Hill		B-1 Buck Hill		
Sample Location	Buck Hill - Milepost	0.4		0.4		
	Material Type	Subgrade		Base		
	Depth	1-5'		0-12", 3-20"		
AASHTO T 11, T 27 & T 88  Washed Sieve Analysis % Passing	3"	75.0 mm				
	1 1/2"	37.5 mm				
	1"	25.0 mm				
	3/4"	19.0 mm		100		
	1/2"	12.5 mm		95		
	3/8"	9.5 mm		89		
	#4	4.75 mm	100	70		
	#8	2.36 mm		56		
	#10	2.00 mm	99	53		
	#16	1.18 mm	99			
	#30	600 µm		38		
	#40	425 µm	98	34		
	#50	300 µm		32		
	#100	150 µm	96			
	#200	75 µm	93	25		
		20 µm				
		2 µm				
		1 µm				
AASHTO T 255	Moisture, %	30.1		24.1		
AASHTO T 89 & T 90	Liquid Limit	47		32		
	Plasticity Index	29		9		
Soil Classification	AASHTO M 145	A-7-6 (28)		A-2-4 (0)		
	ASTM D 2487	CL		SC		
AASHTO T 190	R - Value	<5				
AASHTO T 288	Min. Resistivity, ohm x cm	340				
AASHTO T 289	pH	7.3				
AASHTO T 290	Sulfate Ion Content, %/ppm	0.403 / 4030				
AASHTO T 291	Chloride Ion Content, %/ppm	0.0004 / 4				

**Distribution:** Num. / Project File  
 Laboratory: Darrell Harding  
 Pavements: Danielle Germani  
 Pavements: Steve Deppmeier  
 Materials: Mike Peabody

**Remarks:**

Sulfate & chloride content testing was performed by FHWA consultant, Colorado Analytical Laboratories.

**Reported By:**

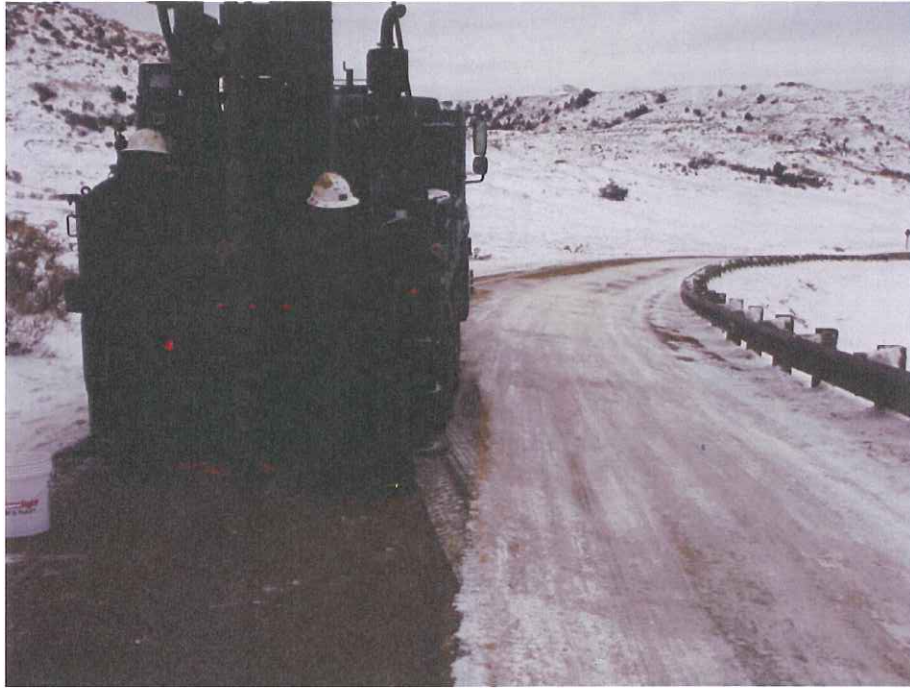
*[Signature]*

Darrell Harding  
Laboratory Manager

## APPENDIX D

### PHOTOGRAPHS (SOUTH LOOP ROAD)

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 26.1 Lt. South Loop Road, B-2, Looking south



MP 26.1 Lt. South Loop Road, B-2, Base Material

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 26.1 Lt. South Loop Road, B-2, Pavement thickness



MP 26.2 Rt. South Loop Road, B-3, looking south

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 26.2 Rt. South Loop Road, B-3, Thermal cracking



MP 26.2 Rt. South Loop Road, B-3, Base material

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 26.2 Rt. South Loop Road, B-3, Base material



MP 27.0 Lt. South Loop Road, B-4, Looking south

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 27.0 Lt. South Loop Road, B-4, Base material



MP 27.5 Rt. South Loop Road, B-5, Looking south

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 27.5 Rt. South Loop Road, B-5, Base material



MP 27.5 Rt. South Loop Road, B-5, Pavement thickness

ND PRA THRO 11 (5) SOUTH LOOP ROAD



Jones Creek Pullout, P-2



Jones Creek Pullout, P-2, Pavement thickness

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 27.9 Lt. South Loop Road, B-6, Looking south



MP 27.9 Lt. South Loop Road, B-6, Base material

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 27.9 Lt. South Loop Road, B-6, Subgrade material



MP 28.6 Rt. South Loop Road, B-7, Looking south

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 28.6 Rt. South Loop Road, B-7, Base material



MP 28.6 Rt. South Loop Road, B-7, Subgrade material

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 28.6 Rt. South Loop Road, B-7, Pavement thickness



MP 6.0 Rt. South Loop Road, B-8, Looking south

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 6.0 Rt. South Loop Road, B-8, Base material



MP 6.0 Rt. South Loop Road, B-8, Pavement thickness

## APPENDIX E

### PHOTOGRAPHS (BUCK HILL SPUR)

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 0.1 Buck Hill Spur, Caved in culvert



MP 0.4 Buck Hill Spur, Culvert

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 0.4 Rt. Buck Hill Spur, B-1, Looking south at dip creating ponding



MP 0.4 Rt. Buck Hill Spur, B-1, Looking south at runoff creating ponding below

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 0.4 Rt. Buck Hill Spur, B-1, Subgrade material



MP 0.5 Rt. Buck Hill Spur, B-2, The shovel shows the rippling in the roadway

ND PRA THRO 11 (5) SOUTH LOOP ROAD



MP 0.5 Rt. Buck Hill Spur, B-2, scoria base material



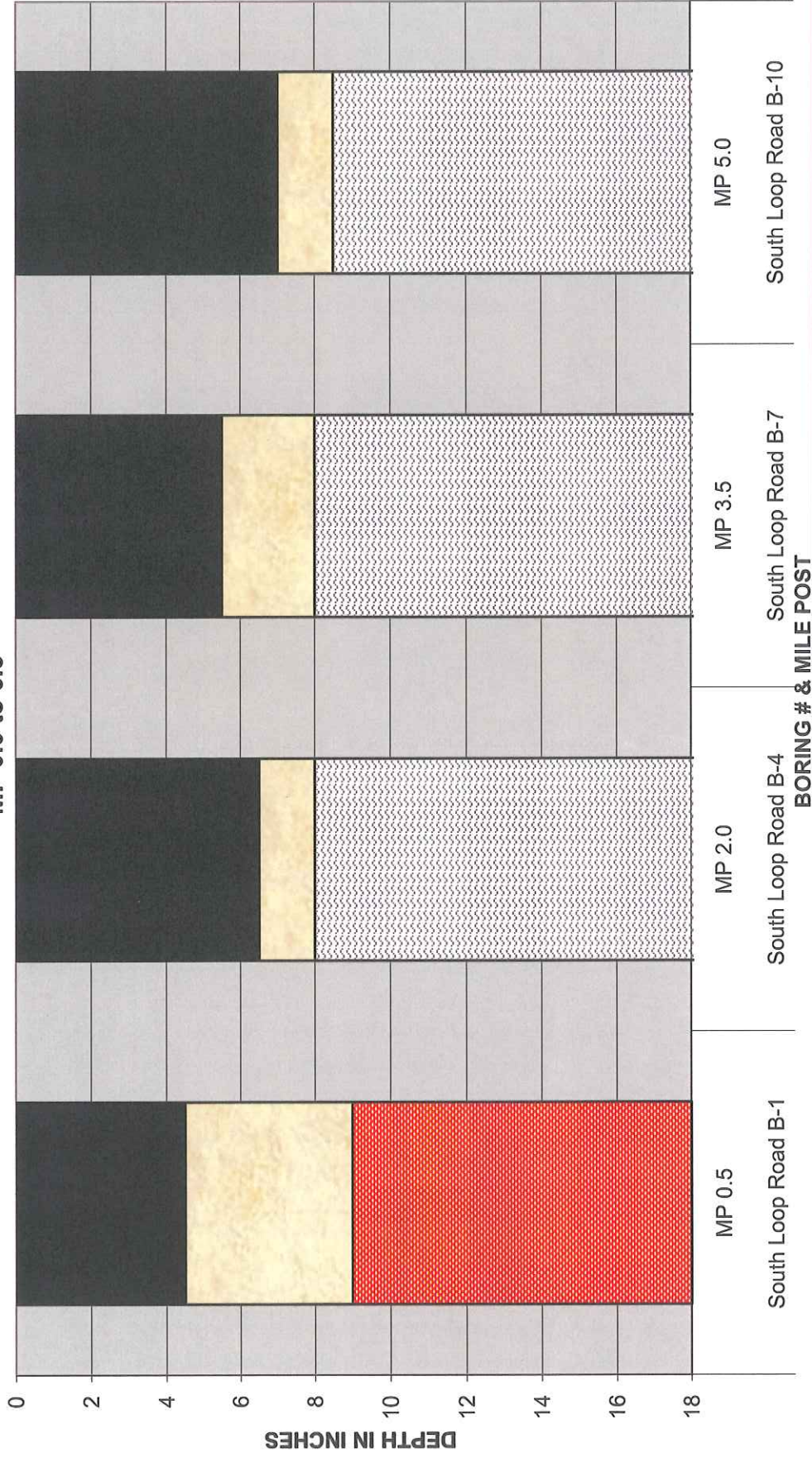
MP 0.5 Rt. Buck Hill Spur, B-2, Subgrade material

## APPENDIX F

### VISUAL CLASSIFICATION SUMMARY

# ND PRA THRO 11 (5) SOUTH LOOP ROAD

## PAVEMENT & BASE COURSE THICKNESSES South Loop Road MP 0.0 to 6.5

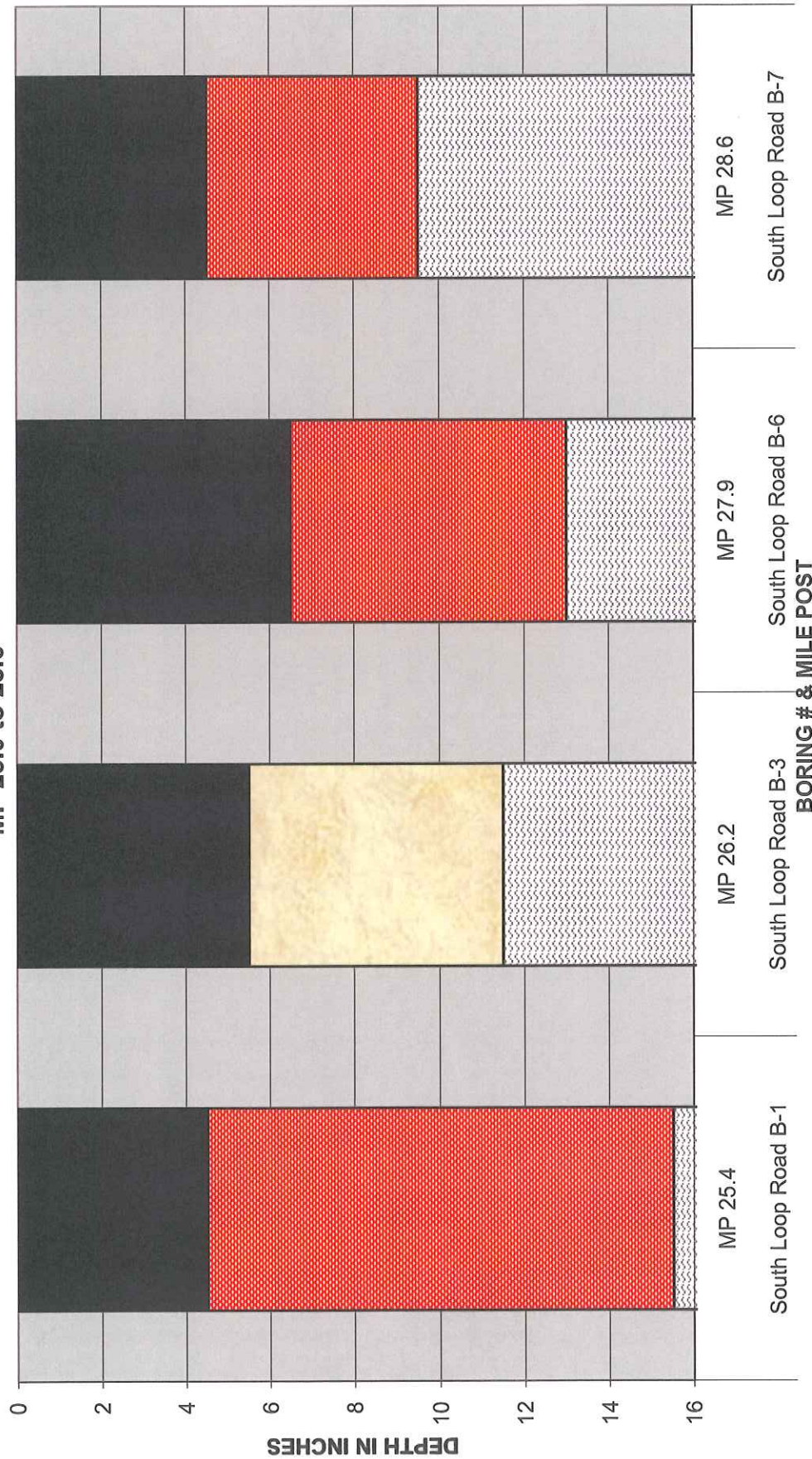


- Existing Pavement
- Base
- Silty Gravel
- Silty Sand

# ND PRA THRO 11 (5) SOUTH LOOP ROAD

## PAVEMENT & BASE COURSE THICKNESSES

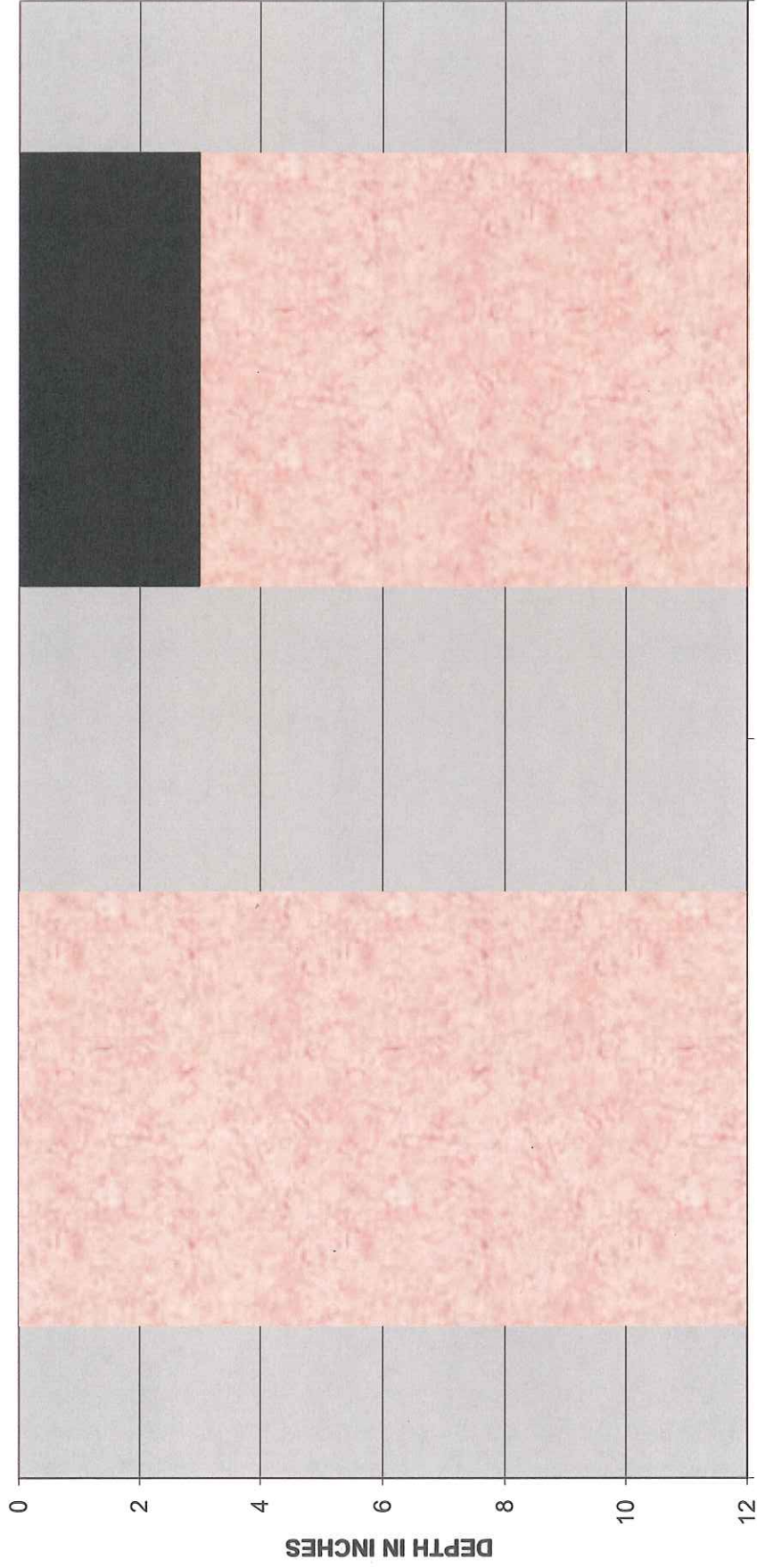
South Loop Road  
MP 25.0 to 28.6



- Existing Pavement
- Silty sand w/gravel
- Silty Clayey Sand
- Silty sand
- Sandy Clay

ND PRA THRO 11 (5) SOUTH LOOP ROAD

PAVEMENT & BASE COURSE THICKNESSES  
Buck Hill Spur



BORING # & MILE POST

■ Existing Pavement ■ Scoria Base

## APPENDIX G

### PAVEMENT DESIGN CALCULATIONS

# 1993 AASHTO Pavement Design

## DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare  
Computer Software Product

### Flexible Structural Design Module

Bucks Hill

#### Flexible Structural Design

18-kip ESALs Over Initial Performance Period	56,095
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,000 psi
Stage Construction	1
Calculated Design Structural Number	2.72 in

#### Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	450
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	92	1	0.0004	0	662
4	1	1	0.88	0	15,838
5	6	1	0.2	0	21,597
7	1	1	1	0	17,998
Total	100	-	-	-	56,095

Growth Simple

Total Calculated Cumulative ESALs 56,095

#### Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	3.5	-	1.54
2	Aggregate base course & stabilizati...	0.2	1	2	-	0.40
3	FDR - Stabilization	0.2	1	4	-	0.80
Total	-	-	-	9.50	-	2.74

# 1993 AASHTO Pavement Design

## DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare  
Computer Software Product

### Flexible Structural Design Module

Option **23** |

#### Flexible Structural Design

18-kip ESALs Over Initial Performance Period	56,095
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,000 psi
Stage Construction	1
Calculated Design Structural Number	2.72 in

#### Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	450
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
CV 2	92	1	0.0004	0	662
RV 4	1	1	0.88	0	15,838
SV 5	6	1	0.2	0	21,597
7	1	1	1	0	17,998
Total	100	-	-	-	56,095

Growth Simple

Total Calculated Cumulative ESALs 56,095

#### Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	3.5	-	1.54
2	FDR - Stabilization	0.17	1	7	-	1.19
Total	-	-	-	10.50	-	2.73

# 1993 AASHTO Pavement Design

## DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare  
Computer Software Product

### Flexible Structural Design Module

Option **2**

#### Flexible Structural Design

18-kip ESALs Over Initial Performance Period	56,095
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	3,000 psi
Stage Construction	1
Calculated Design Structural Number	2.72 in

#### Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	450
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	92	1	0.0004	0	662
4	1	1	0.88	0	15,838
5	6	1	0.2	0	21,597
7	1	1	1	0	17,998
Total	100	-	-	-	56,095

Growth Simple

Total Calculated Cumulative ESALs 56,095

#### Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	4	-	1.76
2	FDR - Pulverize	0.14	1	7	-	0.98
Total	-	-	-	11.00	-	2.74

## APPENDIX H

### PRICE ESTIMATIONS AND ASSUMPTIONS

Theodore Roosevelt-South Loop Road

Average HACP		width	20.50	feet	width		unit weight	lbs to tons	tons	\$ / ton	
Average HACP		depth	6.23	inches	width		unit weight	lbs to tons	tons	\$ / ton	
Option Items		inches convert to feet		feet in mile		width		unit weight		tons	
7" Pulverize		7	5280	x	20.50	x	0.1111	=	12,025	x \$	3.00 = \$ 36,076 (1
4" HACP Lime		4	x 0.0833	x	5280	x	20.50	x	145.2	/	2000 = \$ 261,941 (2
		1%									220 = \$ 5,763 (3
3.5" HACP Lime		3.5	x 0.0833	x	5280	x	20.50	x	145.2	/	2000 = \$ 229,198 (4
		1%									220 = \$ 5,042 (5
Tack		5280	x 20.50	x	0.1111	=	12,025	x	0.1 gal x 1 ton / 241 gal	=	5 = \$ 3742.36 (6
Fog		5280	x 20.50	x	0.1111	=	12,025	x	0.1 gal x 1 ton / 241 gal	=	5 = \$ 3742.36 (7
Prime		5280	x 20.50	x	0.1111	=	12,025	x	0.33 gal x 1 ton / 253 gal	=	16 = \$ 12548.31 (8
Blotter		5280	x 20.50	x	0.1111	=	12,025	x	14.75 lb x 1 ton / 2000 lb	=	89 = \$ 4434.39 (9
											SUBTOTAL = \$ 24,467 (10
7" Stabilization		7	5280	x	20.50	x	0.1111	=	12,025	x \$	5.00 = \$ 60,127 (11
5% Fly Ash		7	x 0.0833	x	5280	x	20.50	x	142.1	/	2000 x 0.05 = 224.30 = \$ 30,281 (12
3% Lime		7	x 0.0833	x	5280	x	20.50	x	142.1	/	2000 x 0.03 = 134.58 = \$ 26,917 (13
Traffic Control											3,000 (14

Option 1  
 3.5" HACP + 7" Fly Ash  
 (2 + (3 + (11 + (12 + (14 =  
 229,198 + 4,584 + 60,127 + 30,281 + 3,000 = \$327,649 per mile Proposed length 10 x \$327,649 = \$3,276,490.35

Option 2  
 3.5" HACP + 7" Lime  
 (2 + (3 + (11 + (13 + (14 =  
 229,198 + 4,584 + 60,127 + 26,917 + 3,000 = \$324,284 per mile Proposed length 10 x \$324,284 = \$3,242,844.62

Option 2  
 4" HACP + 7" FDR - Pulverizing  
 (1 + (2 + (3 + (10 =  
 36,076 + 261,941 + 5,329 + 24,467 = \$328,247 per mile Proposed length 10 x \$328,247 = \$3,282,473.18

Theodore Roosevelt-Buck Hill Spur

Option Items	width		feet		width	unit weight	lbs to tons	tons	\$ / ton	
	inches	convert to feet	inches	in mile						
Average HACP	25.50									
Average HACP	3.00									
2" Aggregate Base Course	2	x 0.083333	x	5,280.00	x 25.50	x 139	/ 2000	= 1569.58	x \$ 40.00	= \$ 62,383 (1)
7" Aggregate Base Course	7	x 0.083333	x	5,280.00	x 25.50	x 139	/ 2000	= 5468.53	x \$ 40.00	= \$ 218,341 (2)
10" Aggregate Base Course	10	x 0.083333	x	5,280.00	x 25.50	x 139	/ 2000	= 7797.9	x \$ 40.00	= \$ 311,916 (3)
3" HACP	3	x 0.0833	x	5280	x 25.50	x 145.2	/ 2000	= 2443.716	x \$ 100	= \$ 244,372 (4)
Lime	1%									
3.5" HACP	3.5	x 0.0833	x	5280	x 25.50	x 145.2	/ 2000	= 2443.716	x \$ 220	= \$ 5,376 (5)
Lime	1%									
4" HACP	4	x 0.0833	x	5280	x 25.50	x 145.2	/ 2000	= 2851.002	x \$ 220	= \$ 285,100 (6)
Lime	1%									
4" HACP	4	x 0.0833	x	5280	x 25.50	x 145.2	/ 2000	= 2851.002	x \$ 220	= \$ 6,272 (7)
Lime	1%									
4" HACP	4	x 0.0833	x	5280	x 25.50	x 145.2	/ 2000	= 3258.288	x \$ 100	= \$ 325,829 (8)
Lime	1%									
4" HACP	4	x 0.0833	x	5280	x 25.50	x 145.2	/ 2000	= 3258.288	x \$ 220	= \$ 7,168 (9)
Lime	1%									
4" Stabilization	4	5280	x	25.50	x 0.1111	= 14,969			x \$ 5.00	= \$ 74,793 (10)
5% Fly Ash	6	x 0.0833	x	5280	x 25.50	x 142.1	/ 2000	x 0.05 = 239.06	x \$ 135	= \$ 32,286 (11)
3% Lime	6	x 0.0833	x	5280	x 25.50	x 142.1	/ 2000	x 0.03 = 143.49	x \$ 200	= \$ 28,699 (12)
Traffic Control										3,000 (13)
				assume \$1000 per day, minimum of 3 days						
3R Option	3.5" HACP + 2" Aggregate Base + 4" Fly Ash									
	(1 + (6 * (7 + (10 + (11 + (13 =									
	62,383 + 285,100 + 6,272 + 74,793 + 32,286 + 3,000				\$463,834 per mile	0.73	x	\$463,834	=	\$338,598.79
3.5" HACP + 2" Aggregate Base + 4" Lime										
	(1 + (6 * (7 + (10 + (12 + (13 =									
	62,383 + 285,100 + 6,272 + 74,793 + 28,699 + 3,000				\$460,247 per mile	0.73	x	\$460,247	=	\$335,980.05
3.0" HACP + 10" Aggregate Base										
	(3 + (4 + (5 =									
	311,916 + 244,372 + 5,376				\$561,664 per mile	0.73	x	\$561,664	=	\$410,014.56
4.0" HACP + 7" Aggregate Base										
	(2 + (6 + (9 =									
	218,341 + 325,829 + 7,168				\$551,338 per mile	0.73	x	\$551,338	=	\$402,476.91

## APPENDIX I

### PRELIMINARY PAVEMENTS MEMO



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

# Memorandum

Subject: **ND PRA THRO-11(5) SOUTH LOOP ROAD**

Date: 2/2/11

From: Steve Deppmeier, Pavements Engineer

In Reply Refer To:  
HFCO-16

To: Mike Will, Project Manager  
Angela Johnson, Designer

The project consists of South Loop Road and Buck Hill Spur in Theodore Roosevelt National Park in Billings County, North Dakota. The project covers 10.67 of South Loop Road, beginning at the Medora park entrance and continuing north. Buck Hill Spur is a 0.73 mile road leading to a scenic overlook.

South Loop Road is also known as Scenic Loop Road (Route 11) in the Road Inventory Program (RIP) data and is labeled as East River Road on most maps. For this memo South Loop Road will be used. Buck Hill Spur is also known as Buck Hill on most maps.

## **Design Assumptions:**

- The Average Daily Traffic (ADT) was provided in the National Park Service (NPS) Traffic Count at Scenic Loop Drive (Medora).
- A 1% ADT growth factor was used to project the traffic data out to 2030.
- The ADT was calculated only using the peak months of May through September.

## **Scenic Loop Road**

Scenic Loop Road project will under go rehabilitation. The traffic loading is 56,000 ESALs from an ADT of 450. The existing pavement depths ranged from 4.5 inches to 9 inches with an average of 6.2 inches. The required design Structural Number (SN) on the subgrade material is 2.72. Below shows two options with Option 1 as the recommended option.

### **Option 1: RECOMMENDED**

3.5 inches HACP

7 inches FDR - Stabilization

SN = 2.73

Cost Estimate (5% Fly Ash) = \$327,649 per mile, paving cost only

Cost Estimate (3% Lime) = \$324,284 per mile, paving cost only

## Option 2:

4 inches HACP

7 inches FDR - Pulverize

SN = 2.74

Cost Estimate = \$328,247 per mile, paving cost only

The recommended pavement rehabilitation is 7-inches of Full Depth Reclamation (FDR) - stabilization with 5% Fly Ash or 3% Lime and 3.5-inches of new Hot Asphalt Concrete Pavement (HACP) overlay. This recommendation is based on traffic information, potential loadings, existing pavement, and soil conditions. This method will provide more stabilization than just pulverization for the clayey soils that are found in this area. This method also provides better constructability and results in a lower grade. The recommendation and cost estimate is for mainline only and does not include paved ditches. Pavement depth may be less for pullouts and parking areas. Provide either 5% Fly Ash or 3% Lime as the stabilizing agent.

It is important to note that the borings were drilled between a quarter and half a mile apart, as a result discrepancies between the report and actual field thickness could occur.

**Buck Hill Spur**

Buck Hill Spur is approximately 0.73 miles long and will undergo rehabilitation. The traffic loading and ADT is the same as for Scenic Loop Road to account for buses that want to drive up to the overlook. Pavement depths ranged from 0 inches in areas where the road has been stripped away to 3 inches.

## Option 1: RECOMMENDED

3.5 inches HACP

2 inches Aggregate Base Course &amp; Stabilization

4 inches FDR-Stabilization

SN = 2.74

Cost Estimate (5% Fly Ash) = \$463,834 per mile, paving cost only

Cost Estimate (3% Lime) = \$460,247 per mile, paving cost only

The recommended pavement rehabilitation is 4-inches of pulverized material, 2 inches of aggregate base course, and 3.5-inches of new HACP overlay. This recommendation is based on traffic information, potential loadings, public access, existing pavement, subgrade, and soil conditions. The existing base material is scoria base with an R-Value of less than 5. It is recommended that 2-inches of base be brought in and placed along the roadway. Provide either 5% Fly Ash or 3% Lime as the stabilizing agent.

A large dip in the road is causing drainage issues and will need to be filled with base material. It will take approximately 7,800 ft<sup>3</sup> of base material to raise the dip. It is also recommended that a culvert be installed in that area. This base quantity does take into account the amount of required base material need to cover the culvert. The cost estimate does not include the cost of this additional base material and culvert. Hydraulics will need to look into the issue further.

### **Pavement Materials**

- 30305-0000 - Pulverizing 7-inch depth.
- 30310-0000 - Fly Ash, Estimate at 142.1 lb/ft<sup>3</sup>.
- 30311-0000 - Lime, Estimate at 142.1 lb/ft<sup>3</sup>.
- 30802-2000 – Roadway Aggregate, Method 2. Estimate at 139 lb/ ft<sup>3</sup>. Place 2-inches of base material at Buck Hill Spur.
- 40101-5600 – Superpave Pavement, ½-inch or ¾-inch nominal maximum size aggregate, 0.3 to <3 million ESALs. Estimate at 145 lb/ft<sup>3</sup>. Asphalt cement will be PG 58-34. Type IV Roughness to be specified.
- 40105-3000 - Antistrip will be Type III (Hydrated Lime at 1%).
- 40920-1000 - Fog Seal, use an emulsion CSS-1, CSS-1h, SS-1, or SS-1h estimate at 0.10 gal/yd<sup>2</sup>
- 41101-3000 - Prime Coat, applied to the FDR-Pulverized material prior to paving. Use and emulsion CSS-1, CSS-1h, SS-1, or SS-1h estimate at 0.33 gal/yd<sup>2</sup>.
- 41106-0000 - Item for blotter control should be included at 14.75 lb/ft<sup>2</sup>.
- 41201-0000 - Tack Coat, HACP shall be placed in two lifts with a tack coat in between lifts. Use an emulsion CSS-1, CSS-1h, SS-1, or SS-1h, estimate at 0.10 gal/yd<sup>2</sup>.

CC: Chuck Luedders, Pavements FDL  
 Steve Deppmeier, Pavements Engineer  
 Mike Peabody, Materials Engineer

Attachment: DARWin Pavement Calculations  
 Log Summary  
 Cost Estimate